

GLAST Large Area Telescope Calorimeter Subsystem

9.0 Product Assurance Implementation Program

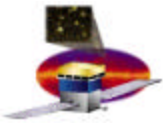
Nick Virmani
Naval Research Lab, Washington DC
Calorimeter Performance Assurance
Manager

nvirmani@swales.com
(202)–767–3455

N. Virmani

Naval Research Lab
Washington DC

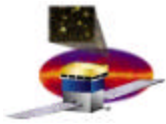




Outline

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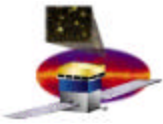




Outline

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- **Risk Mitigation and Risk Assessment**
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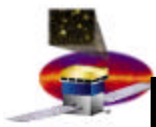




Product Assurance Requirements

- **CAL subsystem Specific Product Assurance Requirements are derived from the GLAST LAT MAR, 433-MAR-001**
- **The CAL specific Quality Assurance Activities and Implementation Plan, LAT-SS-01472-01, describes the methods and controls to be implemented by NRL, collaborators (France and Sweden) and subcontractors**
- **The requirements of GLAST LAT specific Product Assurance Implementation Plan are levied to subsystem collaborators, subcontractors and suppliers**
- **Personnel training and certification to NASA and ESA standards**
- **Identification of risk and evaluation**
- **Support design reviews, manufacturing readiness reviews, test readiness reviews, and pre-ship reviews at NRL, collaborators (France and Sweden) and subcontractors**

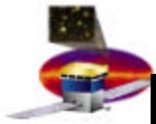




Product Assurance Roles & Responsibilities

- **The Calorimeter Performance & Safety Assurance Manager (PSAM) shall direct and monitor the activities of the LAT CAL subsystem to assure conformance, identify the need for preventive and/or corrective actions, and implement them when necessary**
- **The PSAM is the single point of contact between the Reliability, Quality Engineering Group (QE), the CAL project manager, collaborators (France and Sweden) and subsystem manager for all Safety Reliability and Quality Assurance (SR&QA) issues**
- **The PSAM shall coordinate all Safety, Reliability, and Quality Assurance (SR & QA) issues with the LAT Quality Manager and NASA GSFC GLAST Program System Assurance Manager**

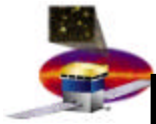




Product Assurance Roles & Responsibilities

- Product Assurance activities include:
 - EEE Parts Engineering and Electronic Packaging
 - Radiation Effects Analysis
 - Reliability Engineering
 - Quality Assurance
 - Review and Inspection
 - Procurement Product Assurance
 - System Safety
 - Material and process control

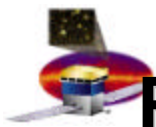




Product Assurance Roles & Responsibilities

- **Product Assurance activities include cont'd:**
 - **Manufacturing and process control**
 - **Nonconformance Control & Reporting using close loop work order database (WOA)**
 - **Problem Report (PR)**
 - **Material Review Board (MRB),**
 - **Waiver,**
 - **Failure Analysis and Corrective Action report (FACR)**
 - **Ground Software Quality Assurance**
 - **Configuration Control**

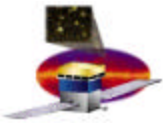




Product Assurance Roles & Responsibilities

- **Verify PWB and workmanship standards**
- **Train and certify personnel on ESD, contamination control, manufacturing processes and procedures**
- **Inspect and witness testing of hardware**
- **Verify test equipment calibration**
- **Conduct surveys and perform surveillance program of collaborators, subcontractors and manufacturers**
- **Provide test software quality assurance**
- **Ensure contamination control requirements are met**
- **Identify, review and approve special processes**
- **Review, approve, and control work orders, problem reports, and failure reports**
- **Verify that collaborators and subcontractors meet all of the above requirements**

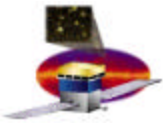




Product Assurance Implementation

- **Methods, procedures and tools have been defined and are being implemented in order to prove that each applicable requirement is verified through one or more methods such as: analysis, inspection, test, review of design, audits**
- **For each configuration item, defined and controlled procedures were implemented during Engineering Model (EM) design, fabrication, and testing for the mission requirements**
- **This will ensure that the design, fabrication, and testing procedures and processes guarantees that the design is producible and verifiable**
- **Before fabrication of flight hardware several peer reviews, manufacturing readiness reviews, and test readiness reviews will be conducted**

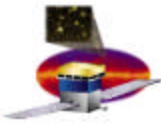




Product Assurance Implementation

- Adequate controls verifiable by QA are established for the procurement of part, components, materials, hardware items, and integration testing of subsystem
- Flight fabrication, integration, test and maintenance will be conducted in a controlled manner so that the end item conforms to the applicable approved procedures and test methods
- All work will be performed using the CAL Work Order Authorization (WOA) database system or equivalent approved system by collaborators (France and Sweden) and subcontractors. A closed-loop nonconformance control system is established and maintained in order to systematically track and prevent reoccurrence. All work orders are controlled and maintained by QA. A similar system will be used by all collaborators

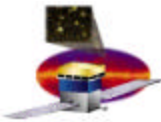




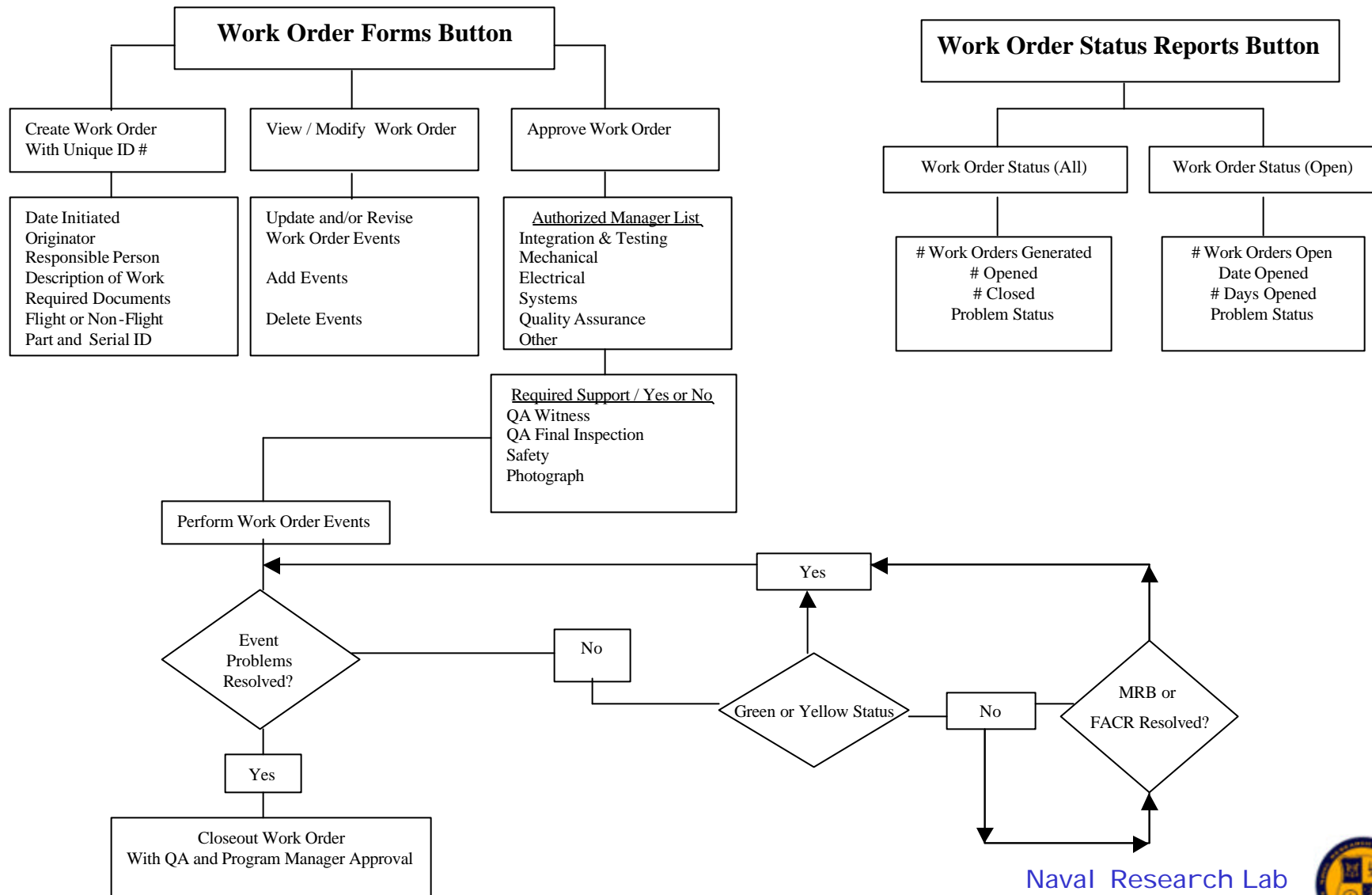
Product Assurance Implementation

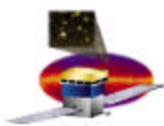
- EM fabrication is being performed using flight WOA system
- Quality records are maintained, analyzed and reported in time to enable preventive/corrective actions to be taken using the work order database system
- Equipment and tools used for flight hardware inspection, measuring and testing project items are calibrated to ensure their accuracy
- Procedures and instructions are established which provide for the identification, segregation, handling, packaging, preservation, storage and transportation of all items





Computer Controlled Work Order and Problem Record Process Flow

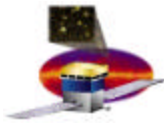




Workmanship & Inspection Requirements

- We will ensure all that assemblers at NRL, collaborators (France and Sweden) and subcontractors working on this project hardware have received the required training and certified to the following standards or equivalent approved ESA standards:
 - NASA-STD-8739.1, Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies (formerly NAS-5300.4(3J-1))
 - NASA-STD-8739.2, Workmanship Standard for Surface Mount Technology (formerly NAS-5300.4(3M))
 - NASA-STD-8739.3, Requirements for Soldered Electrical Connections (formerly NAS-5300.4(3A-2))
 - NASA-STD-8739.4, Requirements for Crimping, Interconnecting Cables, Harness, and Wiring (formerly NAS-5300.4(3G-1))
 - NASA-STD-8739.7, Electrostatic Discharge Control

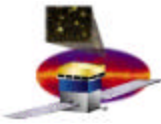




Workmanship & Inspection Requirements

- All flight printed wiring board coupons representative of board panel shall be submitted to GSFC for approval prior to populating the boards
- A work order/traveller must define the steps for QA inspection
- Inspections are performed by QA personnel
- Mandatory inspections are performed for in-house, subcontractor, and collaborator manufactured hardware at predefined inspection points

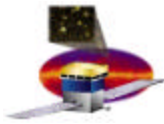




Procurement Product Assurance

- **Procurement Product Assurance Requirements are levied by NRL, collaborators (France and Sweden) and subcontractors to ensure requirements of the project and MAR are met**
- **Participate in kickoff meetings at NRL, collaborators (France and Sweden) and subcontractors, technical review(s), and ensure compliance to requirements**
- **Review collaborators and subcontractors manufacturing processes and procedures**
- **Review collaborators and subcontractors materials / parts requirements and processes**
- **Coordinate PWB coupons testing with GSFC**
- **Establish inspection point(s) and perform customer source inspection**
- **Participate / witness acceptance test(s)**
- **Define end item deliverable package(s)**
- **Participate in pre-Environmental Review and buy-off**

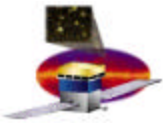




Quality Assurance Surveillance Plan for Collaborators and Subcontractors

- Review and comment on:
 - Evaluate/audit collaborator, contractor, and subcontractor facilities for the ability to consistently produce quality flight hardware daily
 - Maintenance of temperature and humidity monitors
 - Workmanship procedures, processes including all non-standard processes
 - Fabrication and manufacturing procedure
 - Compliance to ESD requirements
 - Material handling and shelf life material storage
 - Data packages and logbooks
 - Nonconformance reporting
 - All travellers/routers
 - Certification for fabrication of hardware

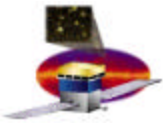




Quality Assurance Surveillance Plan for Contractors and Collaborators

- Support integration and test activities:
 - Manufacturing and test readiness reviews
 - Verify test set-ups
 - Monitor thermal testing when required
 - Witness vibration testing of Qual model
- Verify that electrical and mechanical inspections are performed, which include but are not limited to:
 - Solder workmanship of PDA assemblies
 - Staking applications, bonding of CDEs, verification of bond testing
 - CAL Structure
 - Crystals
 - Testing
 - Configuration verification, as designed v/s as built
 - Pre-ship review of end items and data package

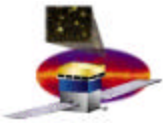




Test Software Quality Assurance

- **Test Software QA functions:**
 - Establish and monitor guidelines, standards, and procedures to ensure processes for testing of ASICs and AFEE boards meet or exceed project requirements
 - Assess the effectiveness of the software development process through audits
 - Report to management on the effectiveness of current processes
 - Attend reviews of test software work products
 - Ensure independent testing occurs
 - Ensure action items are tracked to closure
 - Incorporate improvements into test software procedures
 - Ensure Software Problem Reports (PRs) are maintained, tracked, and closed
 - Ensure Configuration Management processes are followed

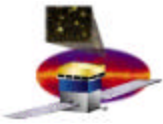




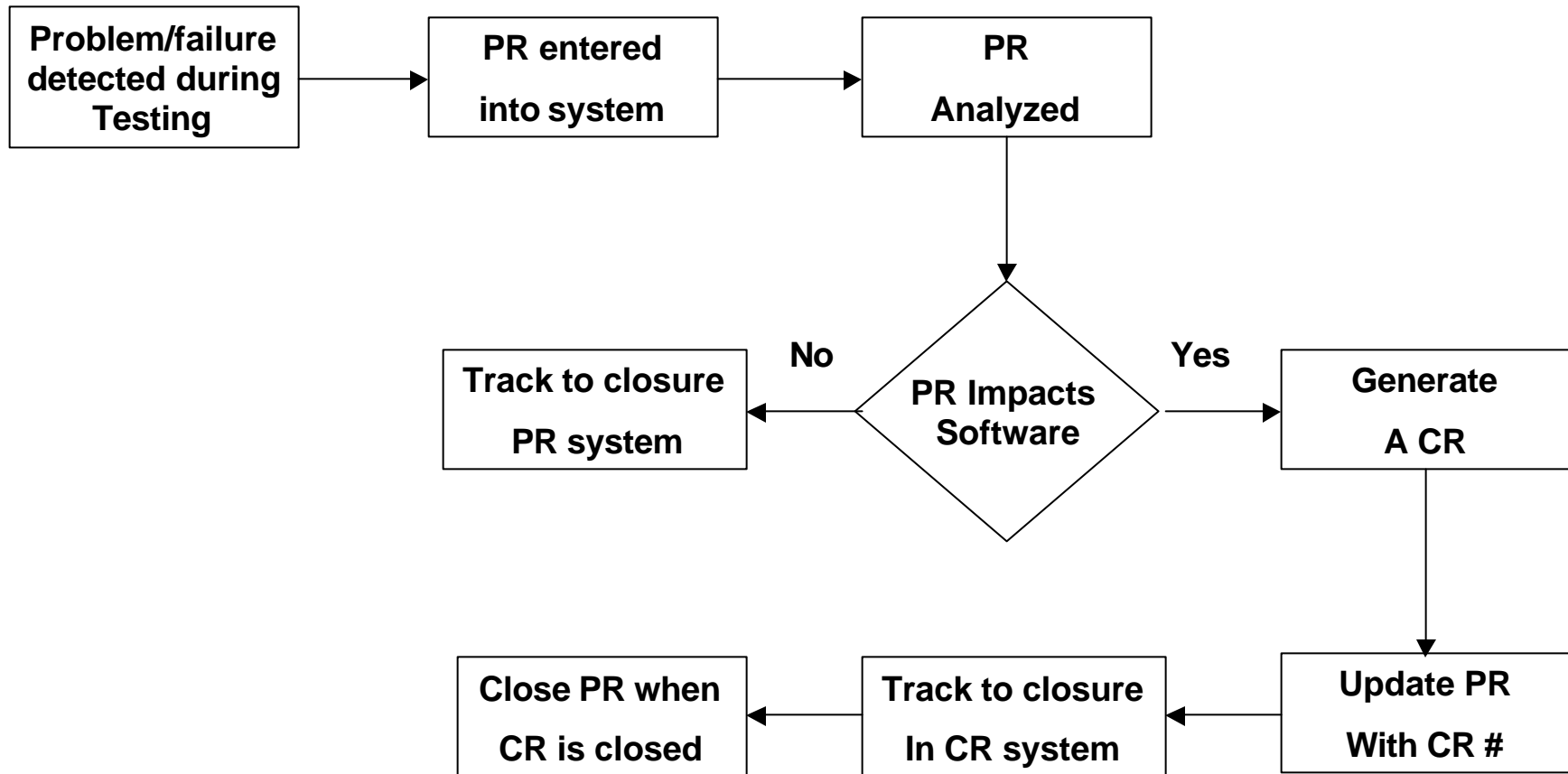
Problem Reporting/Tracking

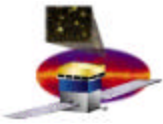
- During development, all problems will be reported through the Problem reporting system
- During testing, problems will be entered in the Problem Report (PR) system
 - Problems or failures attributed to software will require opening a Software Change Request (CR). The CR number will be referenced in the PR. These problems will be tracked to closure as a CR. When work is complete the CR and PR will be closed





PR/CR Process

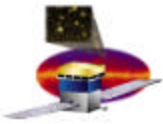




Materials and Process Control

- All flight materials shall meet 1.0%TML, 0.1% CVCM requirements as tested per ASTM E595
- All cured materials must complete proper curing cycles per NASA Reference Publication 1124:
 - **Paints, primers, conformal coatings, adhesives, potting compounds, thermal transfer materials, fastener staking, sealants**
- Review and approve Materials and processes Lists
- Completed and delivered CAL materials lists to GSFC for review and approval
- No non-conventional processes used
- All materials on the material list submitted to LAT/GSFC meets NASA outgassing requirements
- No outstanding issues

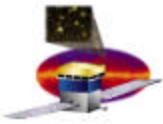




Configuration Management

- Configuration control is defined in the CAL Configuration Management Plan, LAT-MD-01486-01, which defines practices and procedures for drawing releases and changes
- All class 1 changes (major changes that affect mission requirements, system safety, cost, reliability, schedule and external interfaces) shall be approved by the NRL CAL project office. All other changes shall be made available for NRL CAL project review
- The PSAM maintains and tracks all such changes
- CAL project configuration controls and procedures:
 - The baseline configuration is established at the initial release of documents, specifications and drawings by NRL, collaborators, and subcontractors prior to flight fabrication

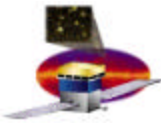




Configuration Management

- **CAL project configuration controls and procedures cont'd:**
 - The CAL project office defines the required review/ approval signatures for drawings, specifications and documentation throughout the project
 - Released drawings, specification and requirements can only be changed through a Engineering Change Notice (ECN)
 - Discrepancy between as- build and as- design hardware will required Material Review Board (MRB) action
 - NRL project Change Control Board (CCB) shall review and process all waiver requests
 - QA will perform in- process configuration audit for in-house, collaborators, and subcontracted items to ensure compliance

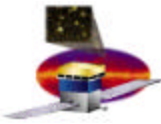




Interface/Configuration Management between Collaborators

- **Interface between France and Sweden configuration management is the process of defining and controlling two or more existing configuration systems that must be connected to each other for Calorimeter configuration system to work**
- **All interface drawings and documents will be in English**
- **To keep track of interfaces, we will be using Interface controlled documents, engineering specifications and ECNs between NRL, Sweden and France**
- **Interface document will define baseline requirements and revision levels for documents agreed between collaborators and NRL for schematics, drawings, procurement, receiving inspection, plans, procedure (test and manufacturing), shipping procedures and report and analysis available for NRL review and approval in English prior to flight fabrication**
- **Any further change in the baseline requirements will require ECN in English for approval from NRL and in some cases by LAT CCB**

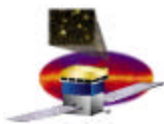




Interface/Configuration Management between Collaborators

- **All schematics, drawings, and plan for mechanical/electrical fabrication testing, etc. work must be reviewed, approved, and released by NRL prior to the start of flight work. Copies of these documents will be assigned LAT numbers and will be controlled by NRL in parallel to the individual configuration control systems at collaborators**
- **NRL configuration management system is the single point of contact for control of documents for the Calorimeter subsystem**
- **ALL NRL personnel and collaborators are responsible for adherence to this procedure defined in configuration management plan**

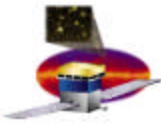




Contamination Control

- Calorimeter contamination control program will be implemented as per LAT-MD-00228-D2, “GLAST LAT Calorimeter, Tracker, & Data Acquisition Contamination Control Plan”, by NRL, supporting collaborators and subcontractors
- Fabrication, assembly and integration of the Calorimeter Subsystem and its components will occur in a minimum of class 100,000 (per FED-STD-209)
 - Molecular witness plates shall be installed in the clean room at least two months before fabrication and assembly
 - Particle witness plates (or equivalent automatic measurement system) shall also be implemented in the clean room
 - Gowning protocol: hood, cleanroom gowns; boots; class 100,000 compatible gloves
 - Assemblies containing crystals, PDAs, and CDEs will be placed in nitrogen purge cabinets when not in use or there is a contamination threat in the local environment

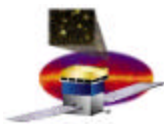




Contamination Control

- Will document all cleaning processes and will not use solvents, materials or aids that would degrade a surface of flight hardware
- Will review all manufacturing and integration processes for contamination hazards
 - Will take protective measures (bagging, nitrogen controlled storage, purging, pre-certification of facilities, etc.) necessary to prevent contamination especially during environmental testing
 - Special emphasis on avoidance of contact transfer of molecular contaminant films (Fabrication Lubricants, Silicones, Human Oils)
- Surface cleanliness verification of flight hardware by optical witness samples, particle fallout plates, tape lifts, and/or NVR Rinses/Swabs

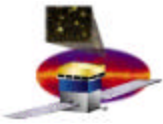




Contamination Control

- On internal and external surfaces of Calorimeter structure, avoid the use of materials and processes that could generate particles
- All personnel performing operations in the clean room will be trained and certified as detailed in the LAT-MD-00228-D2, “GLAST LAT Calorimeter, Tracker, & Data Acquisition Contamination Control Plan”

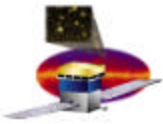




Nonconformance Activities

- The CAL project Material Review Board (MRB) shall determine the disposition of all flight hardware that does not conform to CAL released drawings, specifications or requirements
- MRB is chaired by the PSAM with participation from the lead engineer, design engineer, system engineer and fabrication representative as a minimum
- If “use as is” is the MRB disposition, waiver request should be process through the LAT project Change Control Board (CCB) for review, classification and disposition
- CAL project CCB is chaired by the CAL subsystem manager with participation from the PSAM, lead engineer or design engineer, system engineer as a minimum

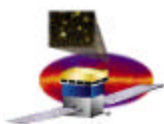




Nonconformance FACR

- **Failure Activities and Corrective Action Report (FACR) is initiated with acceptance testing of a PWB assembly component and continues throughout integration and test of the subsystem**
- **The FACR is the responsibility of the respective lead engineer to document to the Product Assurance Engineer (PAE) for inclusion in the FACR system and to provide resolution**
- **FACR shall be reported within one business day of occurrence**
- **The close-out of all FACRs shall be verified by the PAE through Test Review Board (TRB)**
- **TRB is chaired by the PAE with participation from the lead engineer, test engineer, system engineer as a minimum and LAT project office as required**

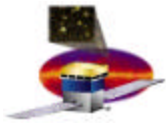




Risk Mitigation and Risk Assessment

- **Each member of the CAL team shares the responsibility to identify, analyze, plan, track, and control risk that could impact the mission**
- **Use of class 2 approved parts meeting derating criteria**
- **Manufacturing using NASA standards with QA surveillance**
- **Verification of engineering model to flight and qualification levels, which includes signal characterization, cross talk or misconnected signals, variation over temperature ranges, EMI, power and ground, vibration and thermal vacuum testing using well defined procedures**
- **Build quality in the design by ensuring that the design is robust, producible, and verifiable**

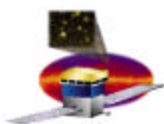




Risk Mitigation and Risk Assessment

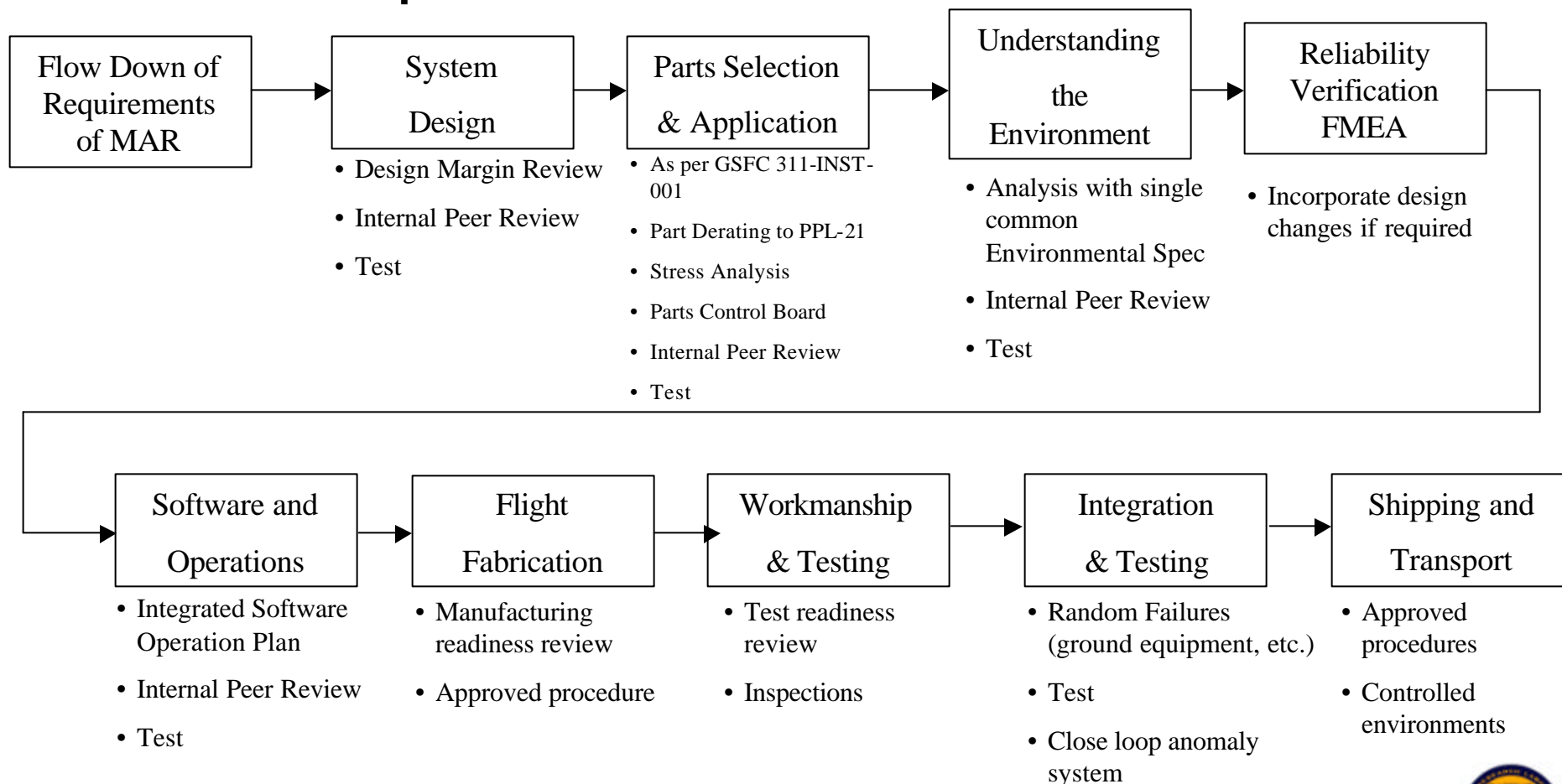
- Test inspection (in-process)
 - Verify procedures approved for use
 - Verify ground support equipment (GSE) is acceptable
- Calibration of all support equipment
- Connector savers, etc
- Keys to success
 - Robust design and verification
 - Manufacturing process control
 - Close loop anomaly review and disposition process
- For details see backup slides

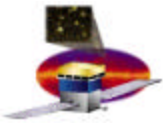




Reliability Program

- Questions answered – what can go wrong, what is likely, what are the consequences

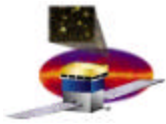




Reliability Program

- A Failure Modes and Effects Analysis (FMEA), preliminary numerical reliability predictions, and sets of Reliability Block Diagrams (RBD) report LAT-TD-00464-03 have been prepared for Calorimeter (CAL) subsystem
- The Failure Mode & Effect Analysis (FMEA) analysis provides a “bottoms-up” look at each CAL component in order to identify potential failures and their effects on a local, CAL, and overall LAT system level
- Specific attention is given to identification of any Single Point Failures (SPFs) that could cause failure of the GLAST Mission
- Only two severity categories are applicable to a CAL – 3R (significant failure modes but operational redundancy is available) and 4 (minor failure modes)
- In general, CAL failure modes are many-failure tolerant

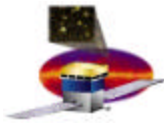




Reliability Program

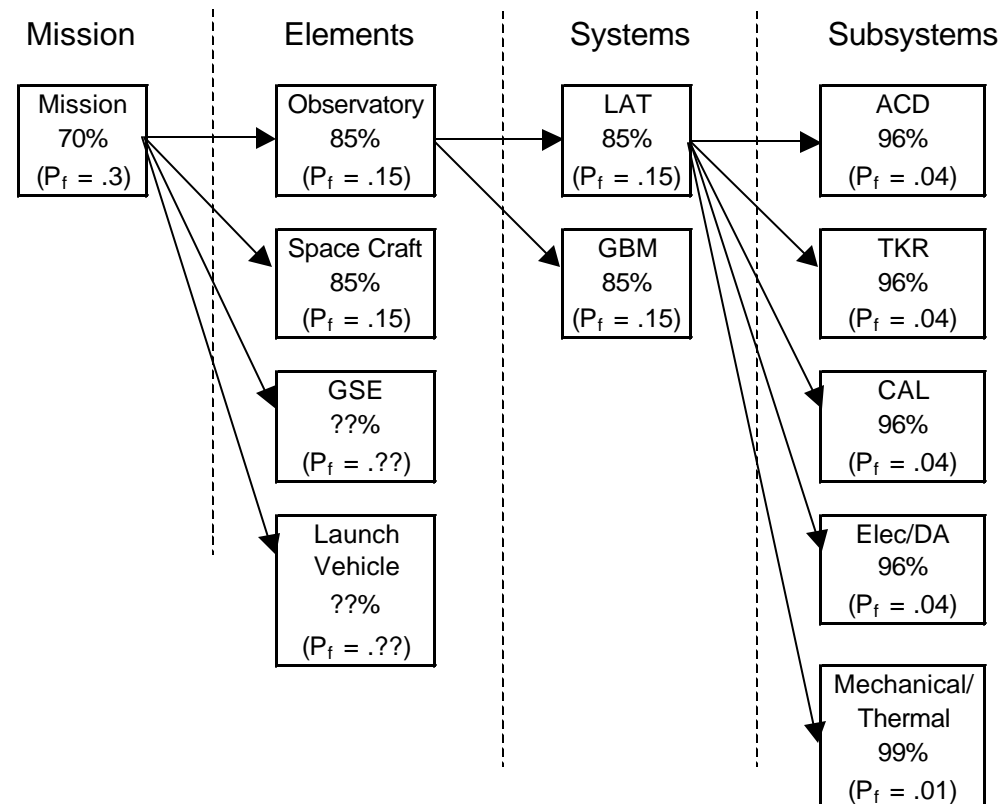
- Architecturally, the TEM is not part of the CAL and such TEM failures are not CAL failure modes and are not counted
- The CAL subsystem does not have a single point failure mode
- The CAL subsystem meets LAT reliability allocation of 96% for five year mission
- Details were provided in the Electrical presentation





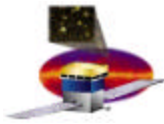
SLAC GLAST Reliability Allocation Flow

Reliability Allocation



Reliability - is defined as the probability of successfully meeting mission objectives at end of life. P_f is probability of failure.

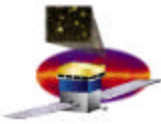




Calorimeter EM Hardware Fabrication & Testing Status

- Pre EM (VM₁ & VM₂) Structure built in France to well defined procedures and methods meets the mission requirements
- EM structure being assembled at NRL is also built to well defined procedures and meets the stress and thermal analysis requirement and will be tested along with assembled CAL EM
- We do not foresee any problems with the EM structure
- French collaborators IN₂P₃ procedures meet the MAR requirements
- CDEs assembled at Swales to well defined and controlled procedures meet the mission requirements
- 14 CDEs supplied by CEA France meet optical test requirements and are part of the CAL EM subsystem being assembled at NRL
- CEA CDE assembly which includes PIN photodiode assembly, bonding to crystal assembly procedures, processes, and inspection criteria for subcontractor facility to be prepared and reviewed prior to flight fabrication

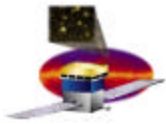




Calorimeter EM Hardware Fabrication & Testing Status

- **PIN Photodiodes and CDE assemblies were tested at NRL for an extended period of time with no failures**
- **EM AFEE Electronic board and board assembly was performed using well defined hand soldering procedures**
- **AFEE board thermal analysis meets the system requirements and no modifications are required in the design due to thermal analysis**
- **EM AFEE boards are in testing and will be integrated on subsystems**
- **Testing will be performed using well defined procedures**
- **All of the above work is being performed using a computer controlled, well documented work order system. All anomalies are recorded and corrective action taken for flight**
- **EM vibration testing and thermal vacuum procedures are in review process**
- **We do not expect any surprises**
- **No outstanding issues**

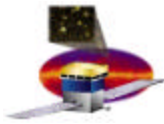




Issues / Concerns

- **Issues and mitigation plan have been defined during this presentation and beyond those following are the issues for flight**
- **Procedures, fabrication, and assembly of PIN photodiode at France have yet to be qualified**
- **CDE bonding and testing procedures have yet to be qualified**
- **New subcontractors selected for these processes have yet to be qualified**
- **New versions of ASICs have yet to be tested and verified for performance**
- **Vendors for surface mount assembly to be approved and certified**
- **EM testing and results**





Summary

- **Calorimeter subsystem will be built to well defined, proven, and controlled procedures**
- **All EEE parts and electronic packaging processes are in place**
- **So far EM testing results have given us confidence and we do not expect any surprises**
- **Quality is never an accident. It is the result of high intention, sincere effort, intelligent direction and skillful execution by the CAL team members to achieve mission success**

